



A Field Study of Biochar Amended Soils: Water Retention and Nutrient Removal from Stormwater Runoff

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National Fish and Wildlife Foundation grant

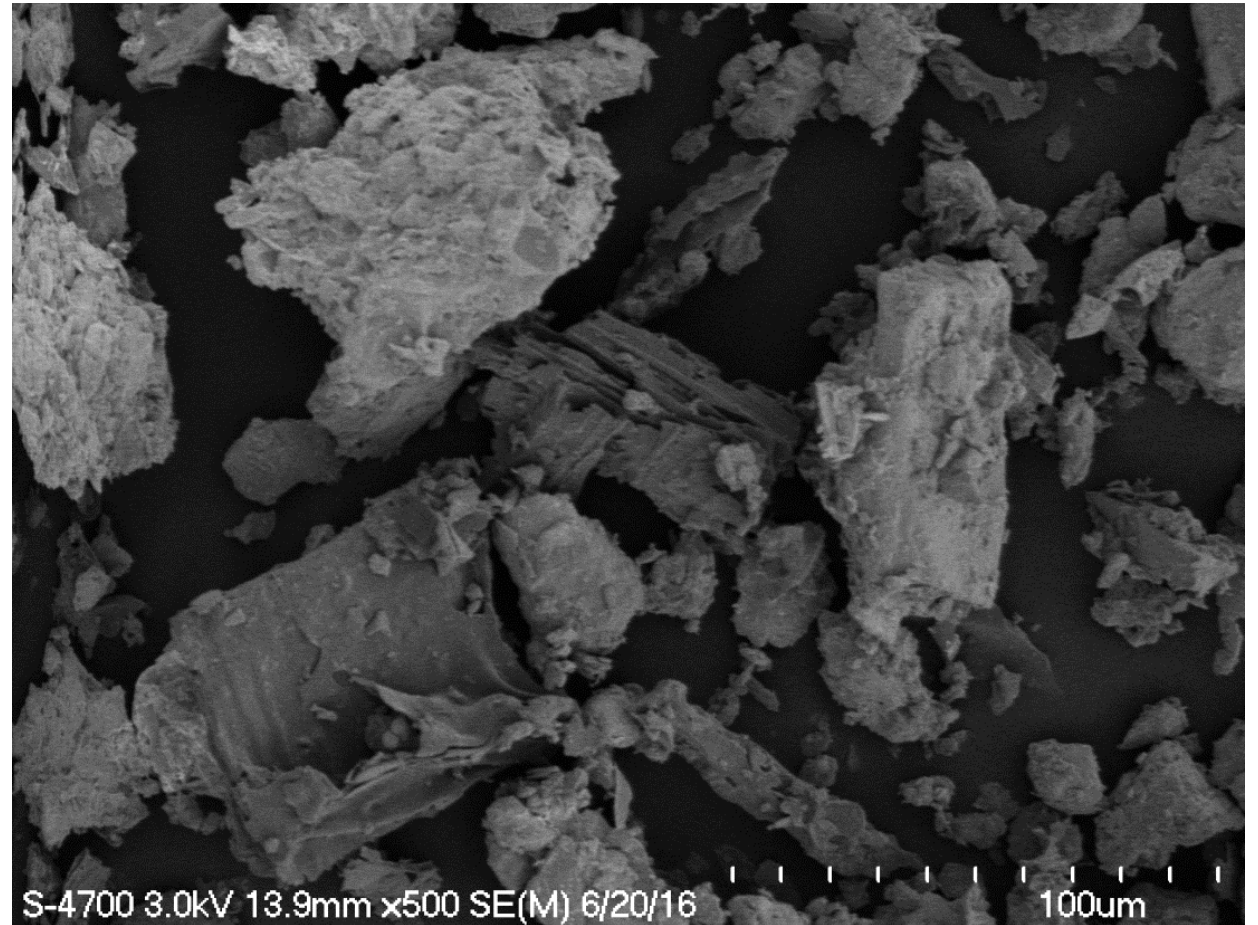
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Outline

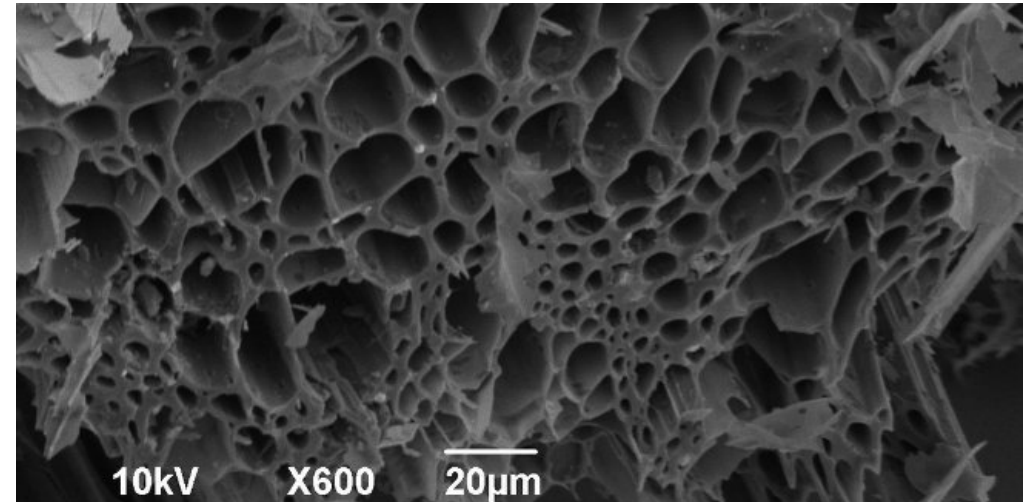
- Background
- Research Hypotheses
- Experimental Methods
- Preliminary Results
- Future Research





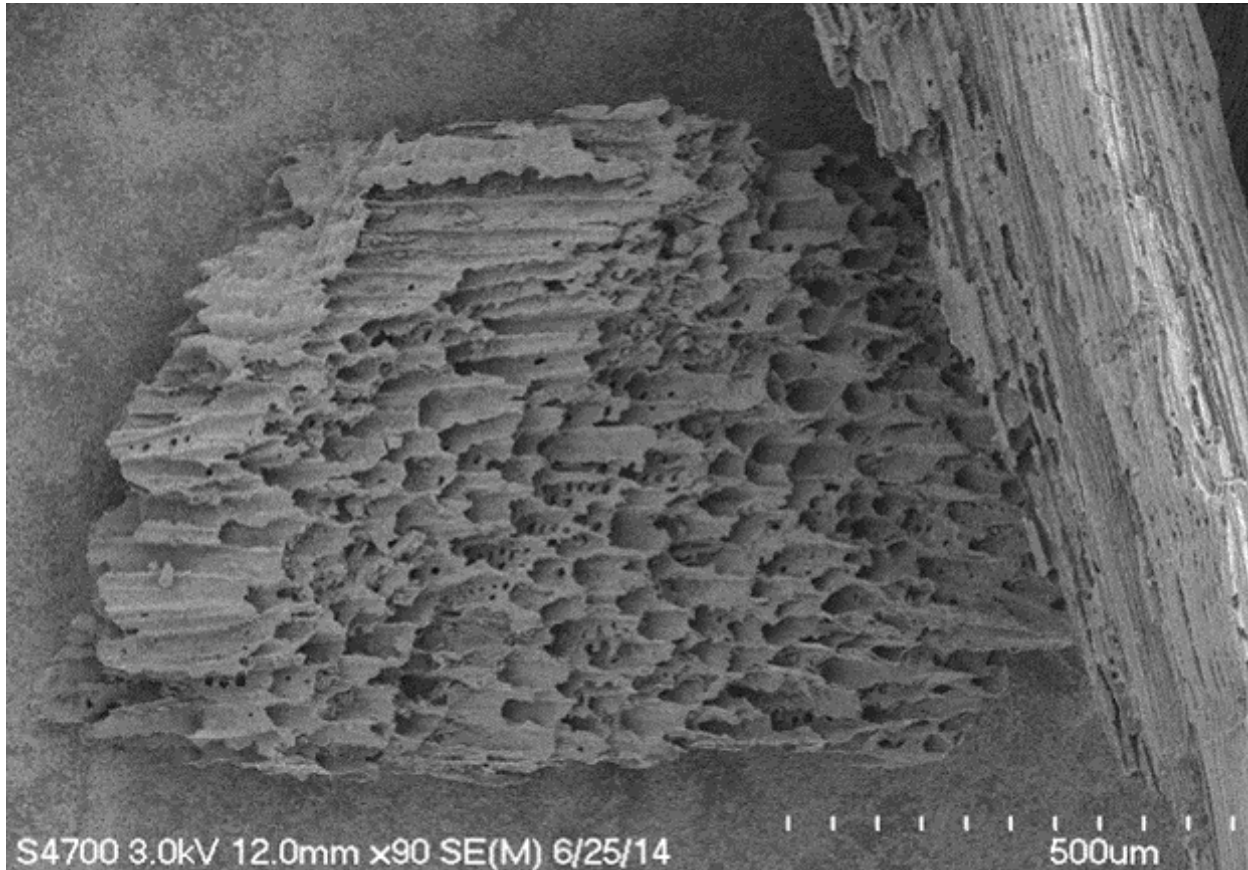
What is Biochar?

- Produced from the pyrolysis of wood or waste biomass
- Important properties
 - High surface area
 - High porosity
 - Significant cation exchange capacity
 - High adsorption capacity
 - Stable carbon structure





Biochar's Potential Benefits:

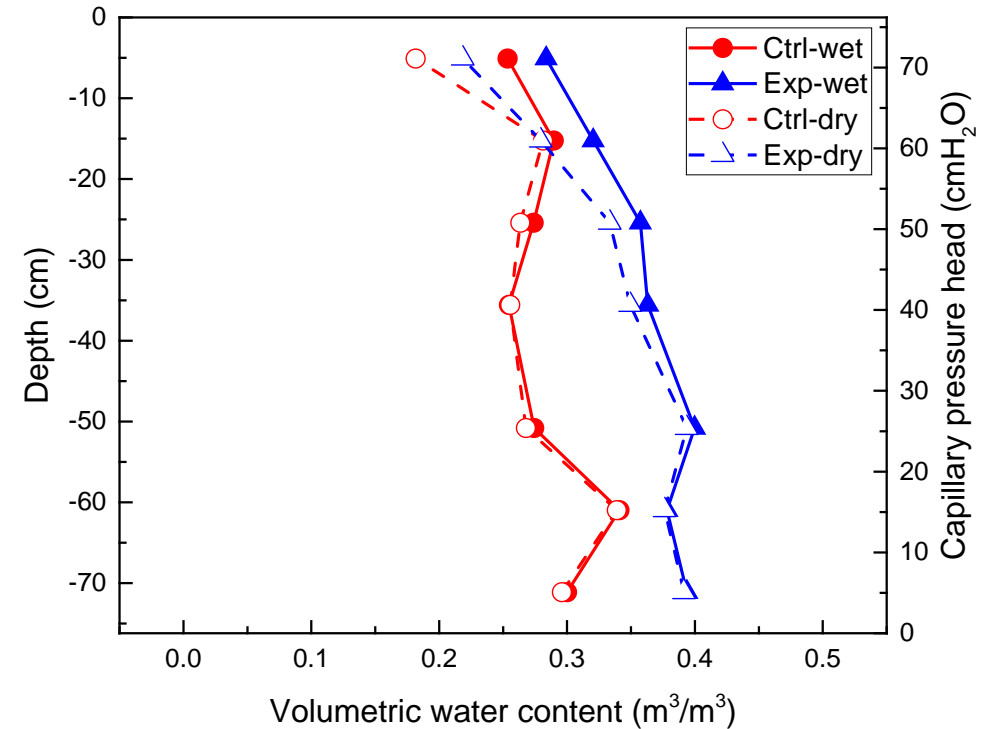


- Decreased overall stormwater runoff rates & volumes
- Reduced soil erosion and sedimentation
- Reduced nutrient & metal loading
- Improved groundwater recharge
- Reduced flooding



Background Research

- Biochar Impact on Soil Hydraulic Properties:
 - K_{sat} Increased 4X
 - Water Retention Increased 30%
- Impact on Nutrient Removal
 - 43% NO_3 Reduction
 - 6.1% *increase* in NO_3 in control cell without biochar



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Research Hypotheses:



Roadside Filter Strips:

- Biochar increases
 - water retention
 - unsaturated hydraulic conductivity
 - hydraulic residence time of pollutants in soils

Roadside Swales:

- Biochar increases
 - water retention
 - hydraulic residence time

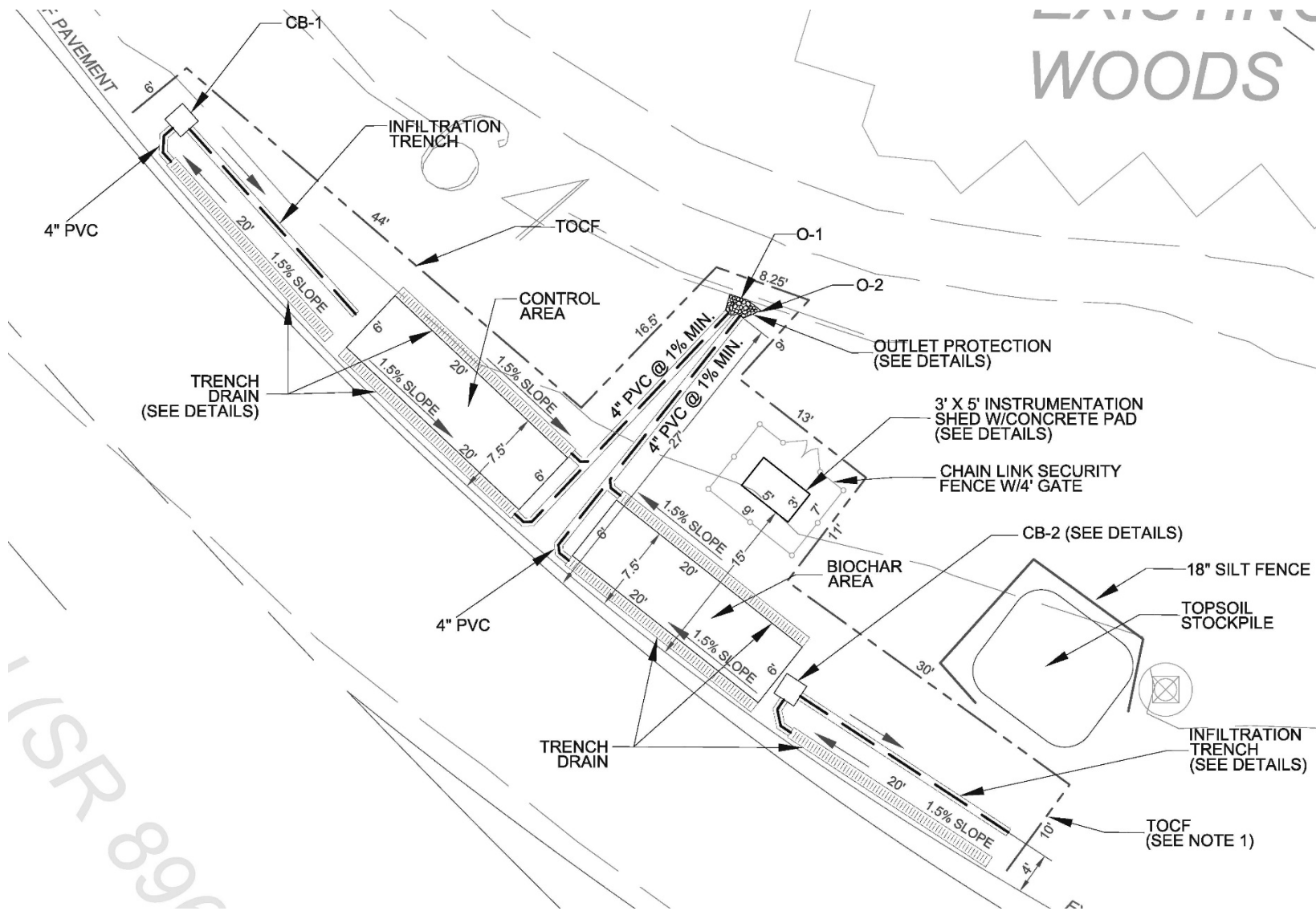


Project Site: Rt 896 & Bethel Church Road Middletown, De





Experimental Methods - Filter Strips



Test Equipment:

- Soil Moisture sensors
- Water potential & temperature sensors
- Automated water samplers
- Ultrasonic flow sensors
- Rain gauge

(SR 89)



Experimental Methods - Filter Strips





Experimental Methods – Roadside Filter Strips



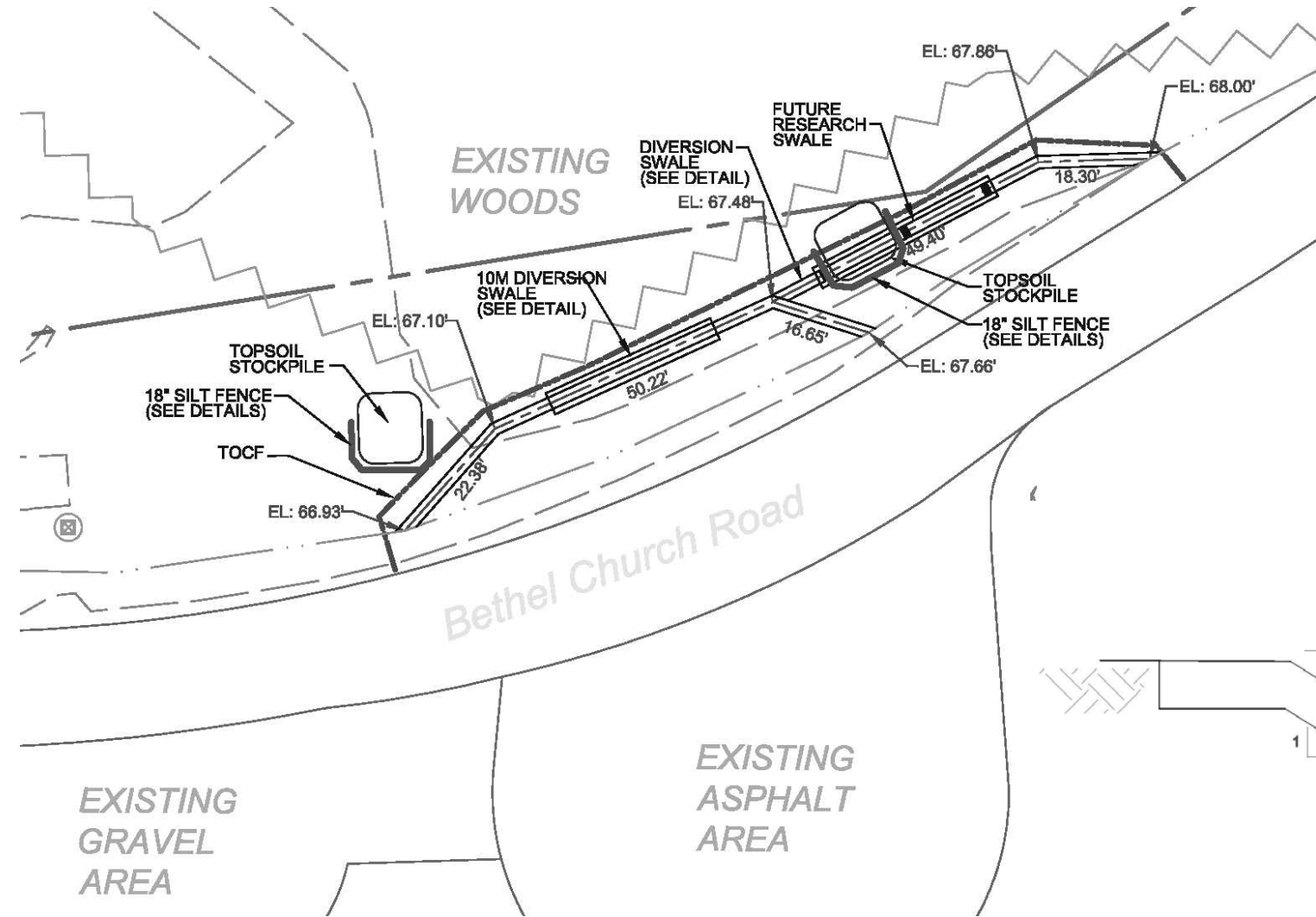
Control Strip



4% Biochar Strip

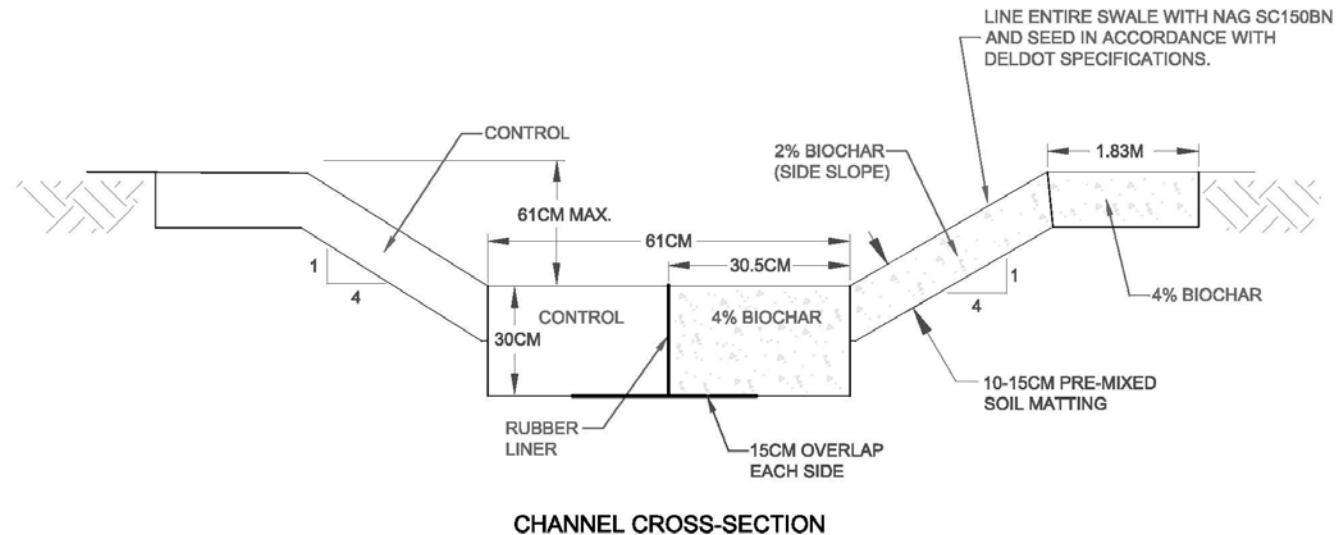


Experimental Methods - Swale



Test Equipment:

- Soil Moisture sensors
- Rhizon Pore Water Samplers
- Rain gauge



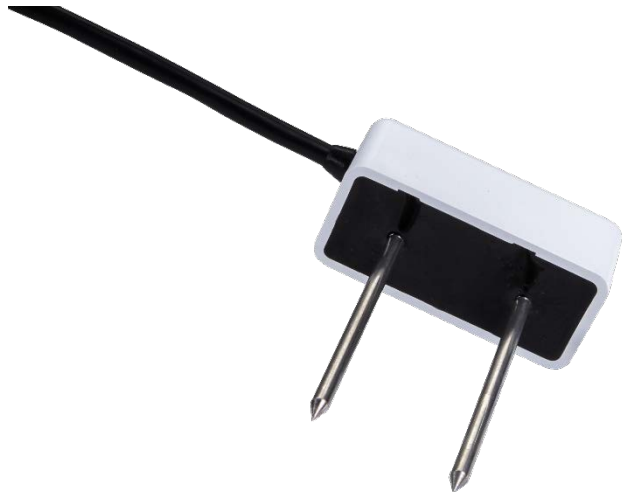


Experimental Methods - Swales





Experimental Methods - Parameters:



Soil Data:

- Volumetric Water Content
- Soil Water Potential
- Soil pH and Temperature
- Electrical Conductivity
- Soil Compaction
- Unsaturated Hydraulic Conductivity
- Nitrogen Compounds in Pore Water

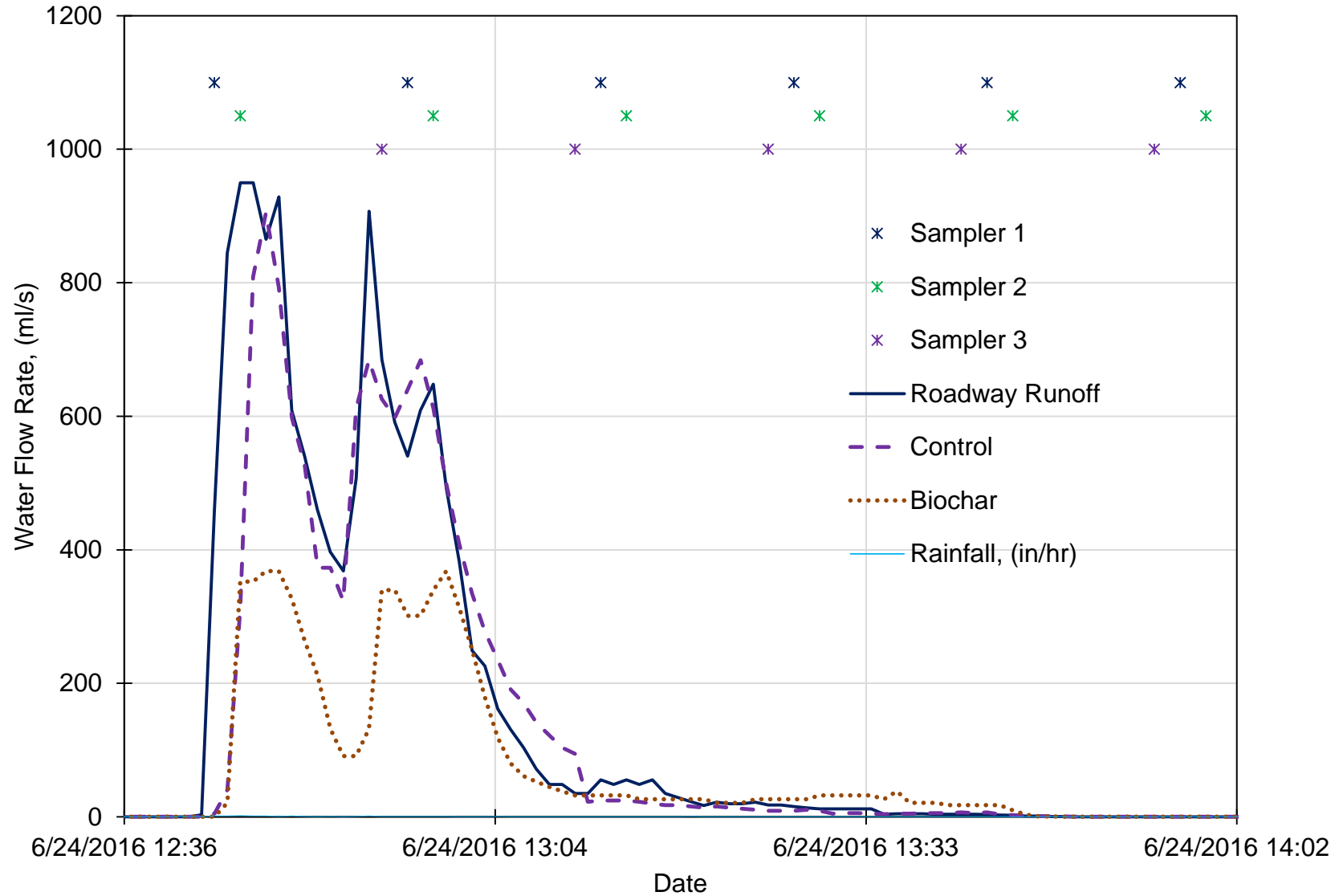
Surface Water Data:

- Stormwater Runoff Rate and Volume
- Influent and Effluent N Loading
(Total N, NH_3 , NO_3 , NO_2 , TOC, etc.)
- Total Suspended Solids



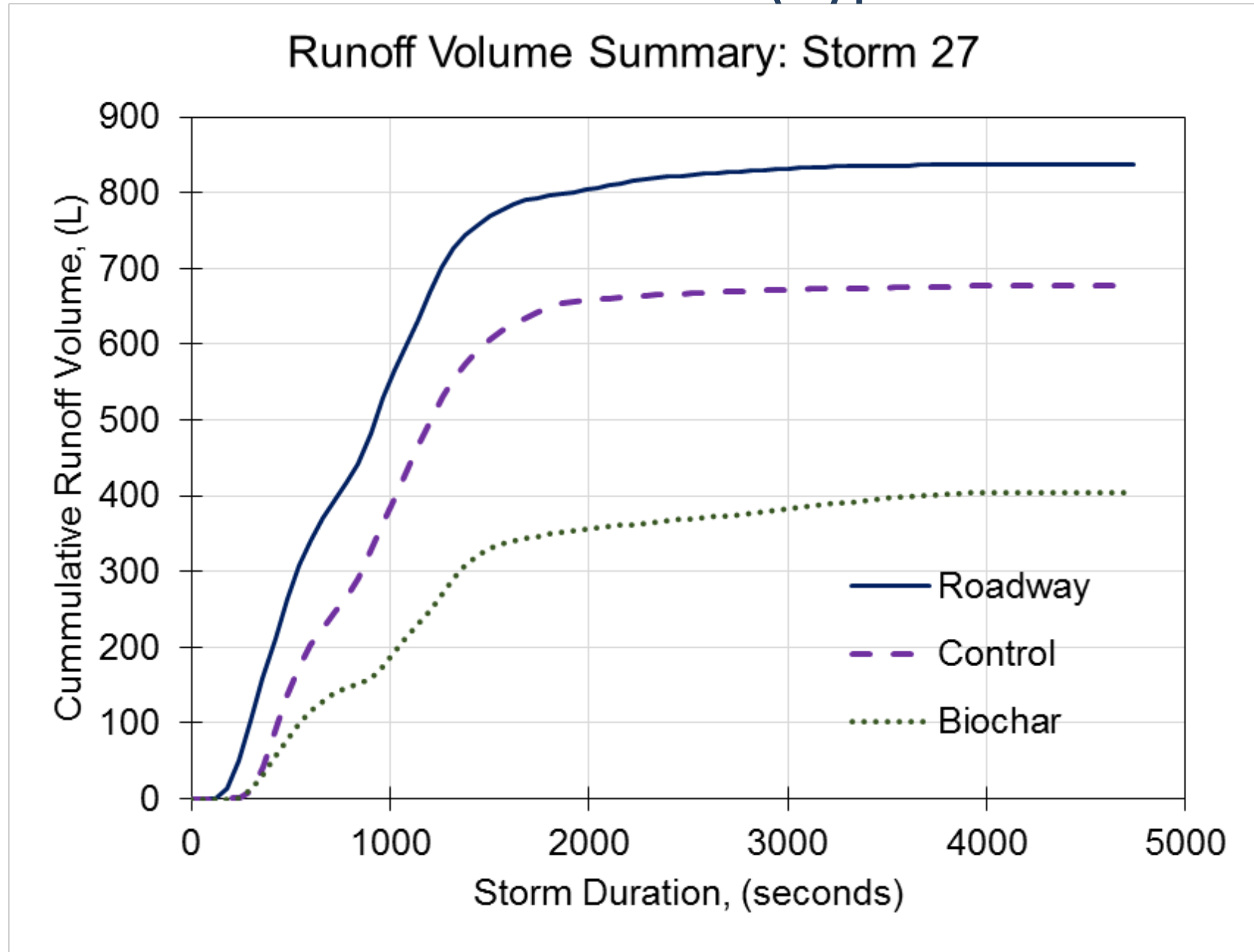
Results – Runoff Profile (Typical Rain Event)

Storm Event 27: Area Flow Rates





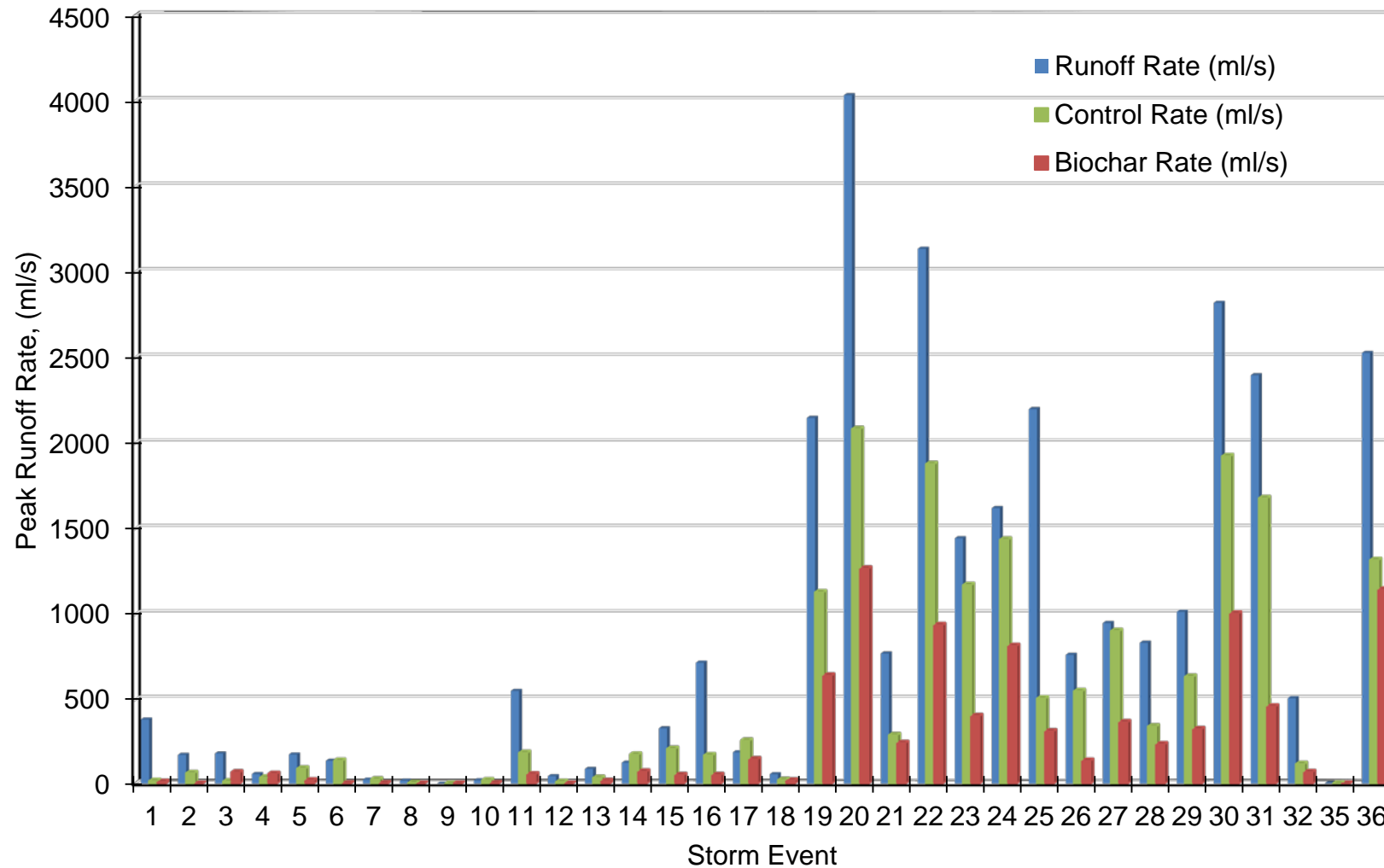
Results – Cumulative Runoff (Typical Rain Event)





Stormwater Runoff Summary

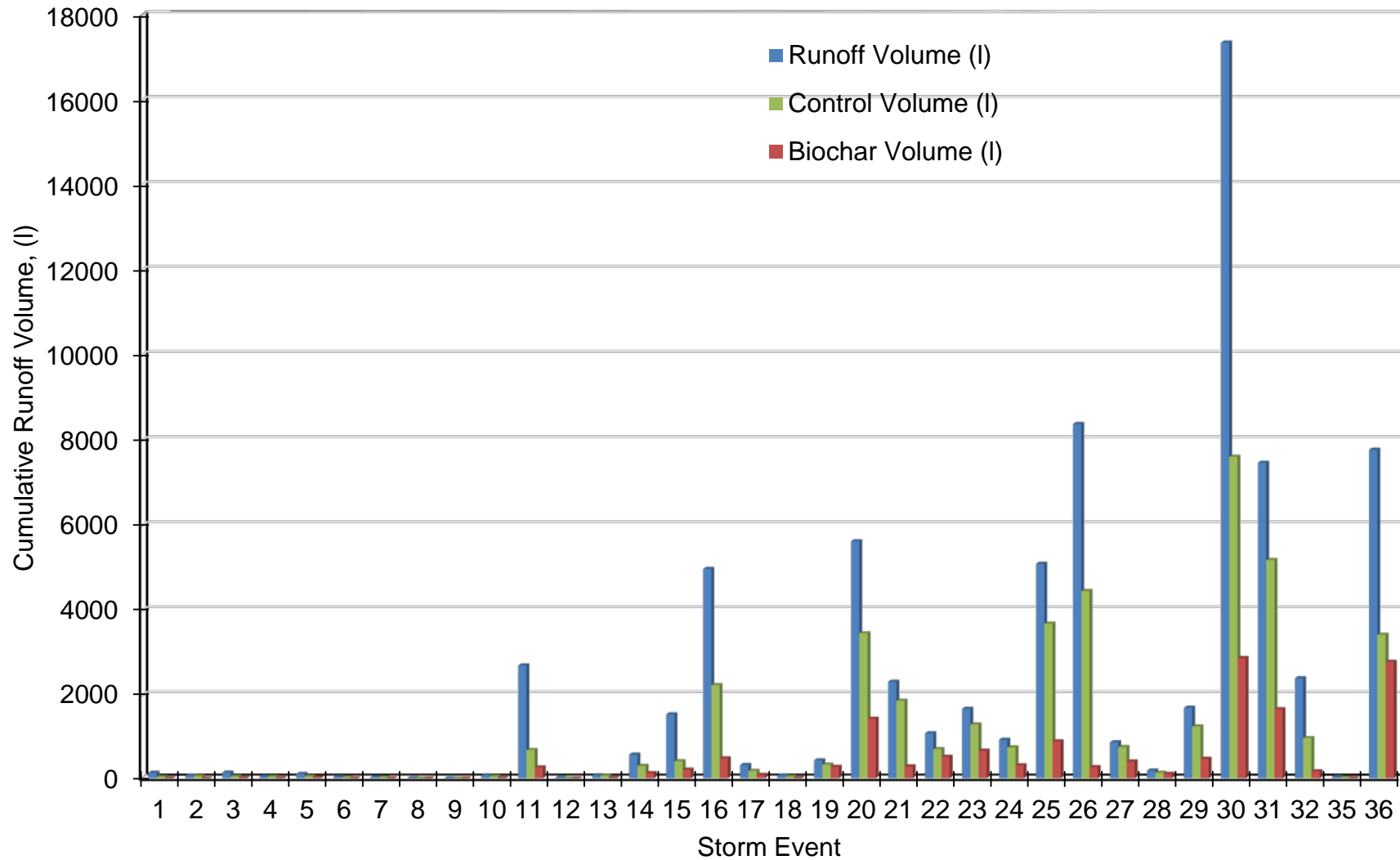
Peak Runoff Rate Summary





Stormwater Runoff Summary

Runoff Volume Summary





Stormwater Runoff Summary

Results for 34 Rain Events

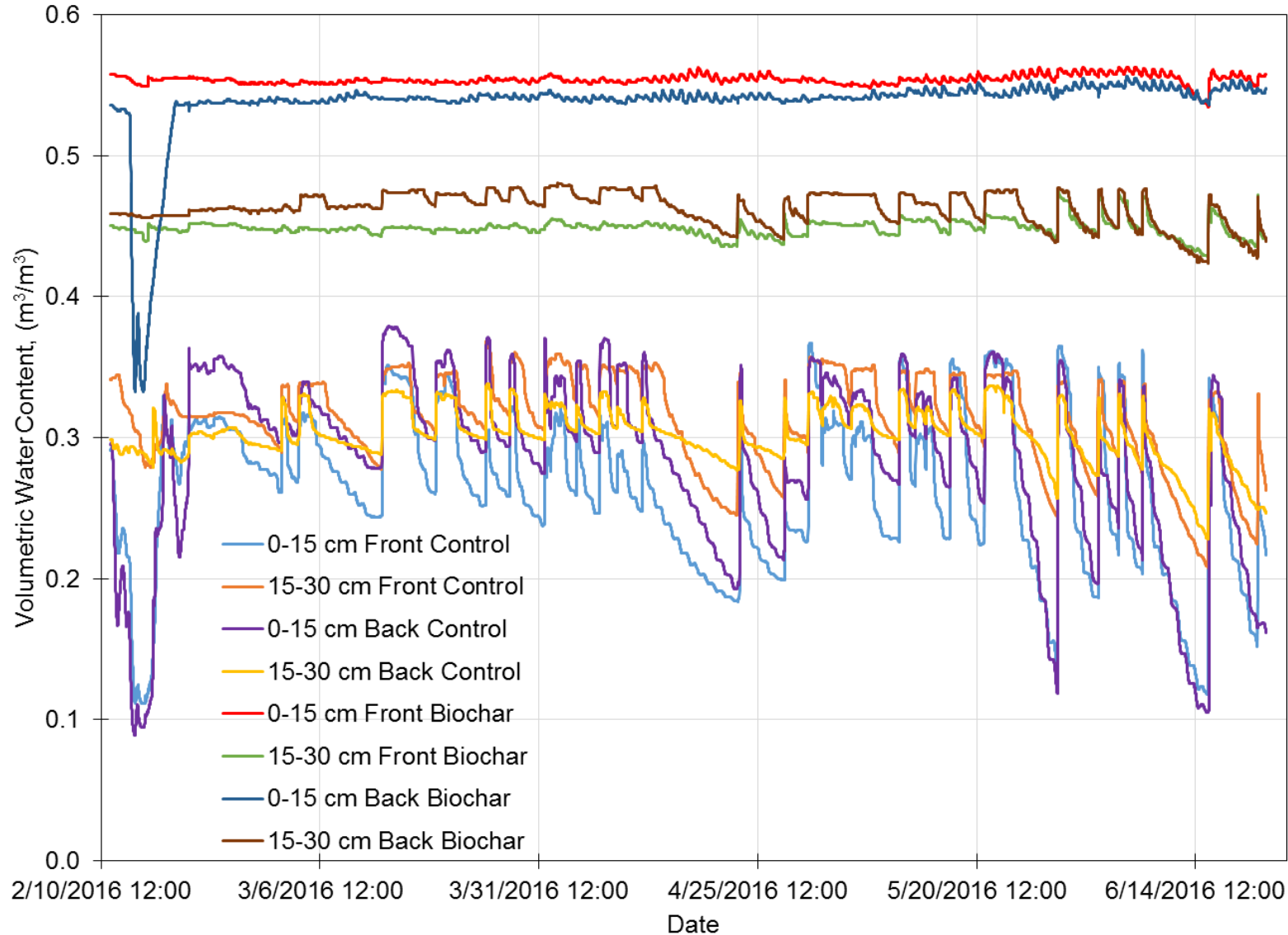
- Average Peak Stormwater Runoff Rate Reduction:
43% (Std Dev: 28%)
- Average Cumulative Stormwater Runoff Volume Reduction:
68% (Std Dev: 24%)





Results – Soil Moisture Content

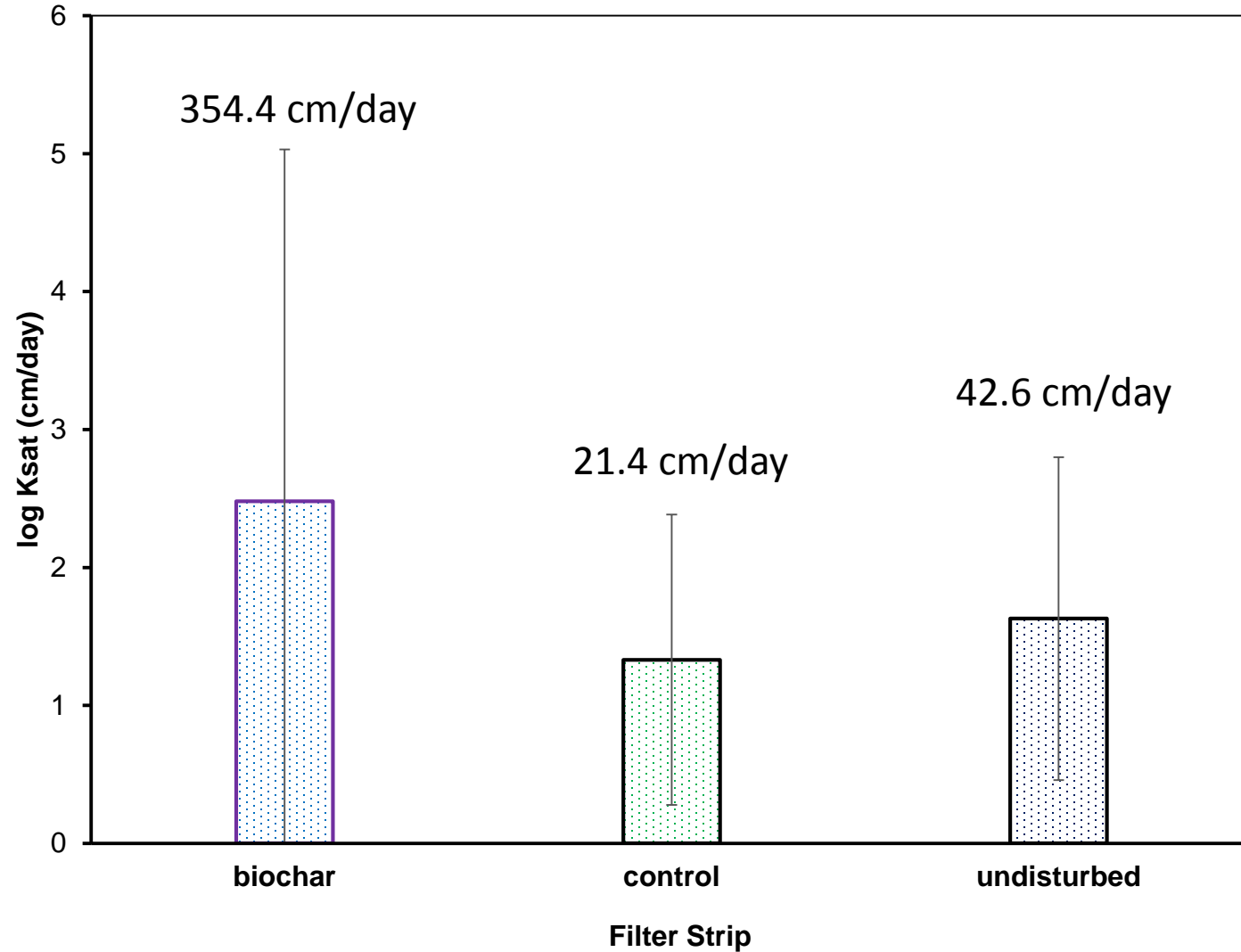
NFWF Soil Moisture Content



- 0-15cm Depth: 83% Increase
- 15-30cm Depth: 50% Increase



Results – Infiltration

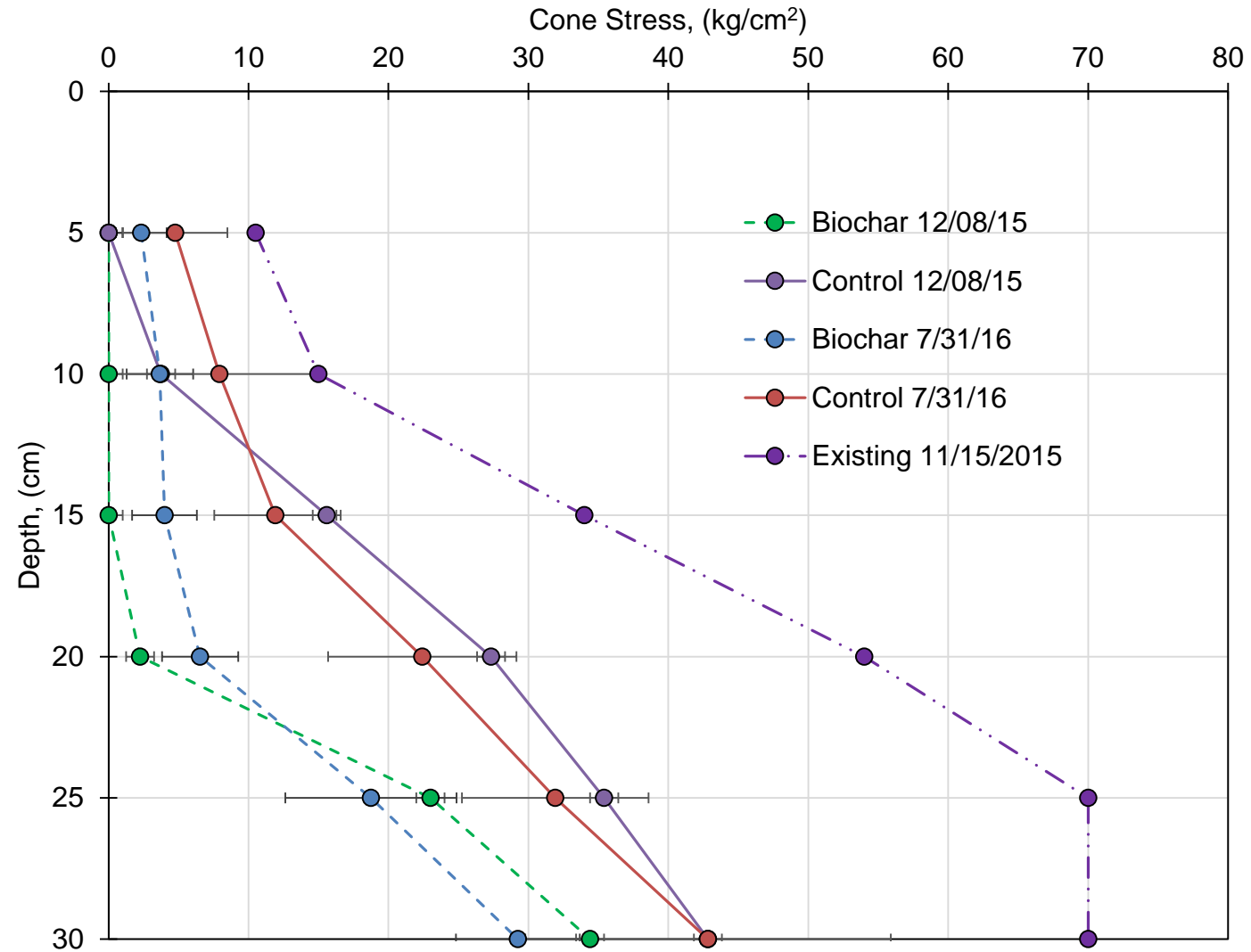


- Tillage: 50% Reduction
- Biochar: 732% Increase



Results – Compaction

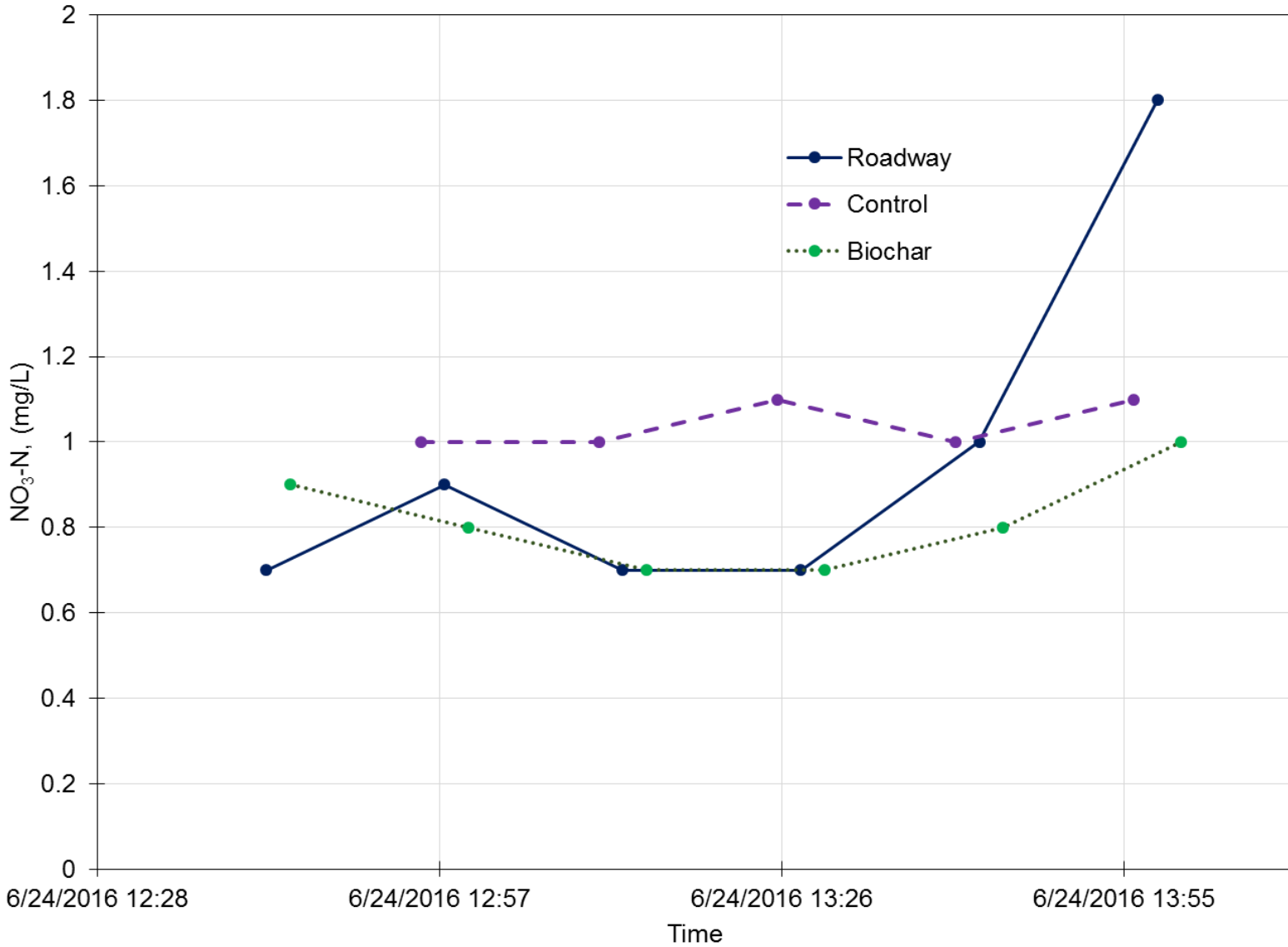
Compaction Testing Summary





Results – NO₃ –N Concentration(Typical Rain Event)

NO₃-N: Storm 27

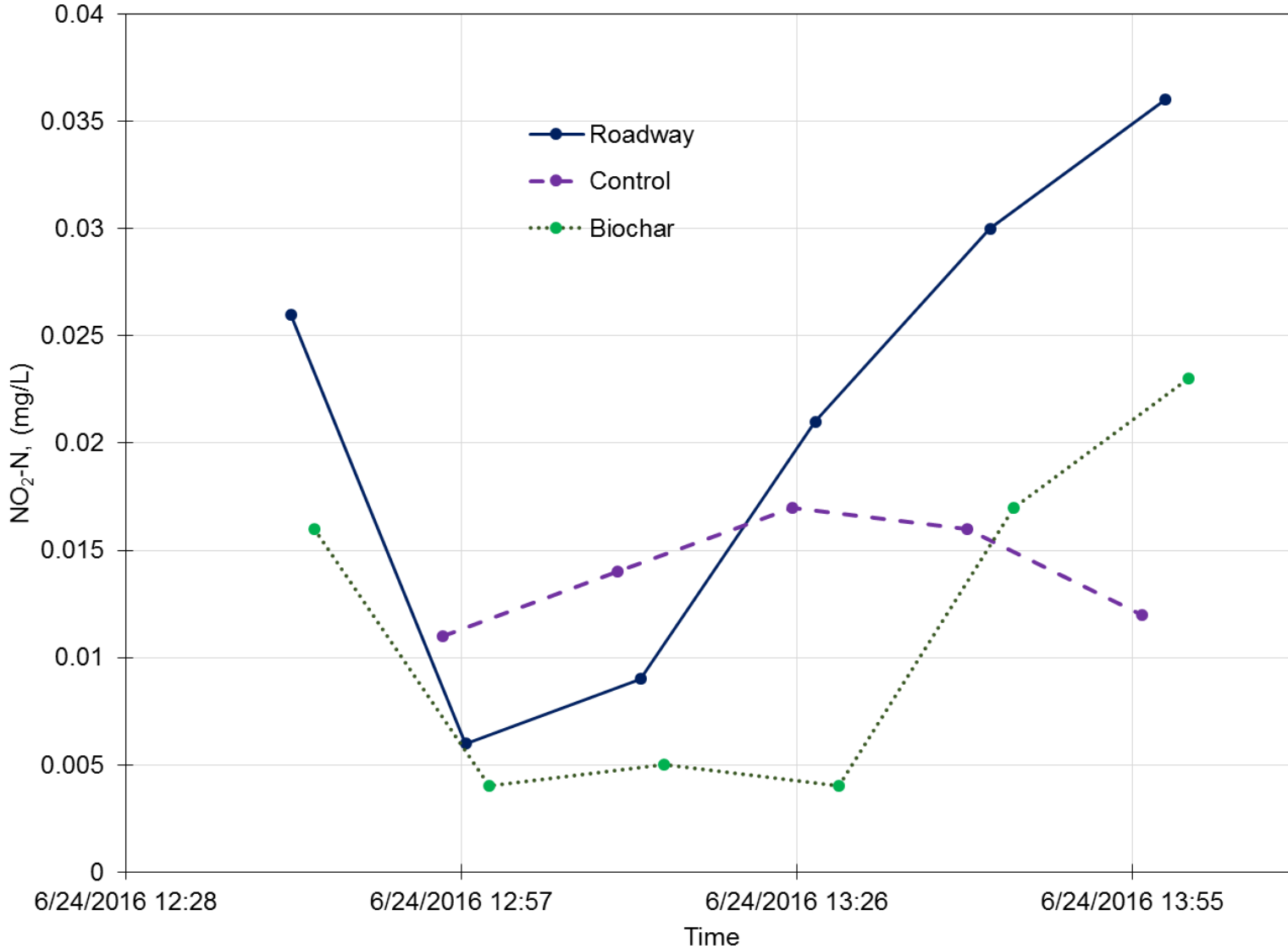


- 23% NO₃ Reduction



Results – NO₂ –N Concentration(Typical Rain Event)

NO₂-N: Storm 27

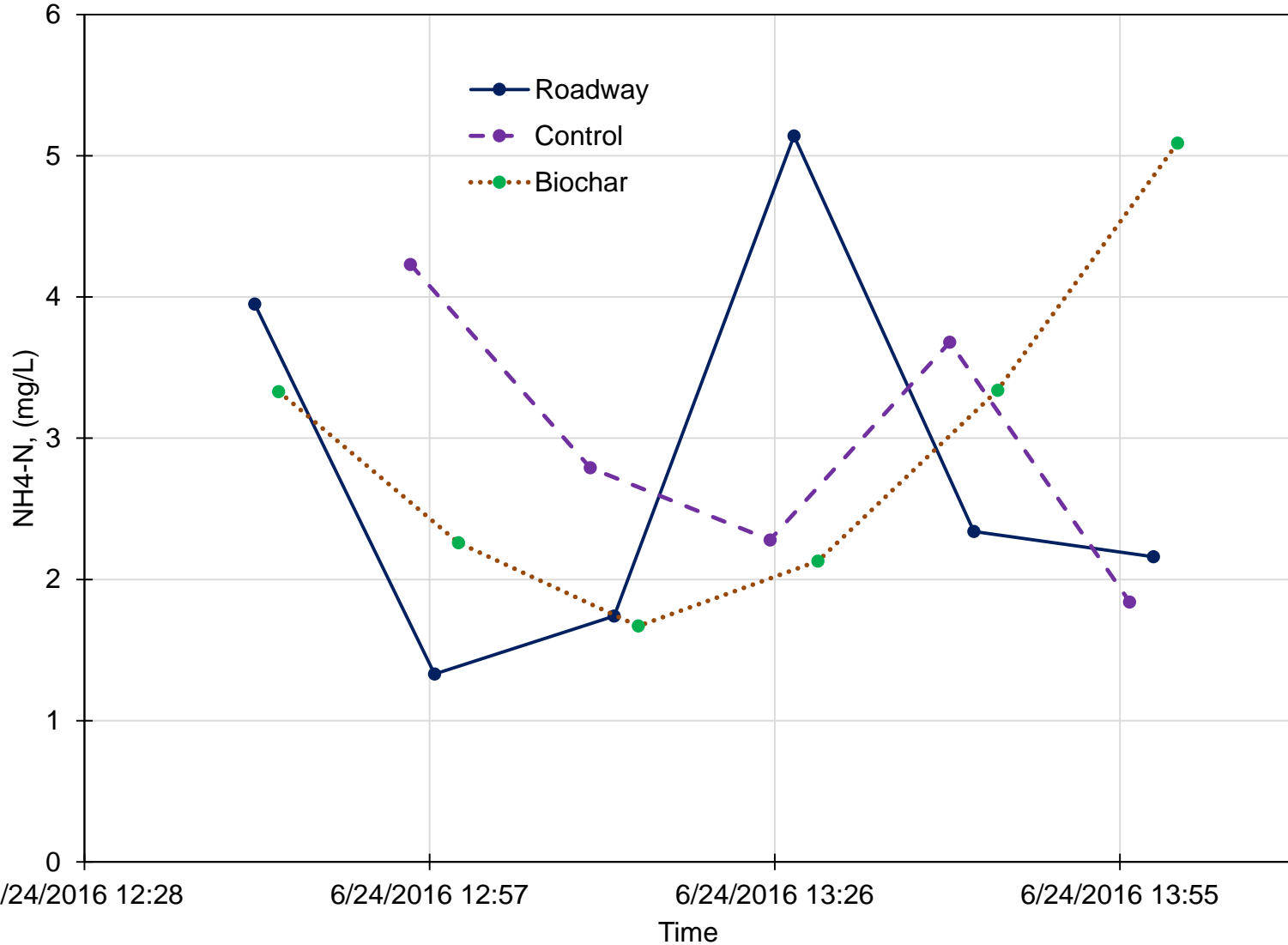


- 21% NO₂ Reduction



Results – TN (Typical Rain Event)

TN: Storm 27



- 26% TN Reduction (First 80% of Storm)
- 15% TN Increase (Overall)



Results – Grass Growth



Control Strip (4/25/2016)



4% Biochar Strip (4/25/2016)



Results – Dissecting Microscopic Imagery



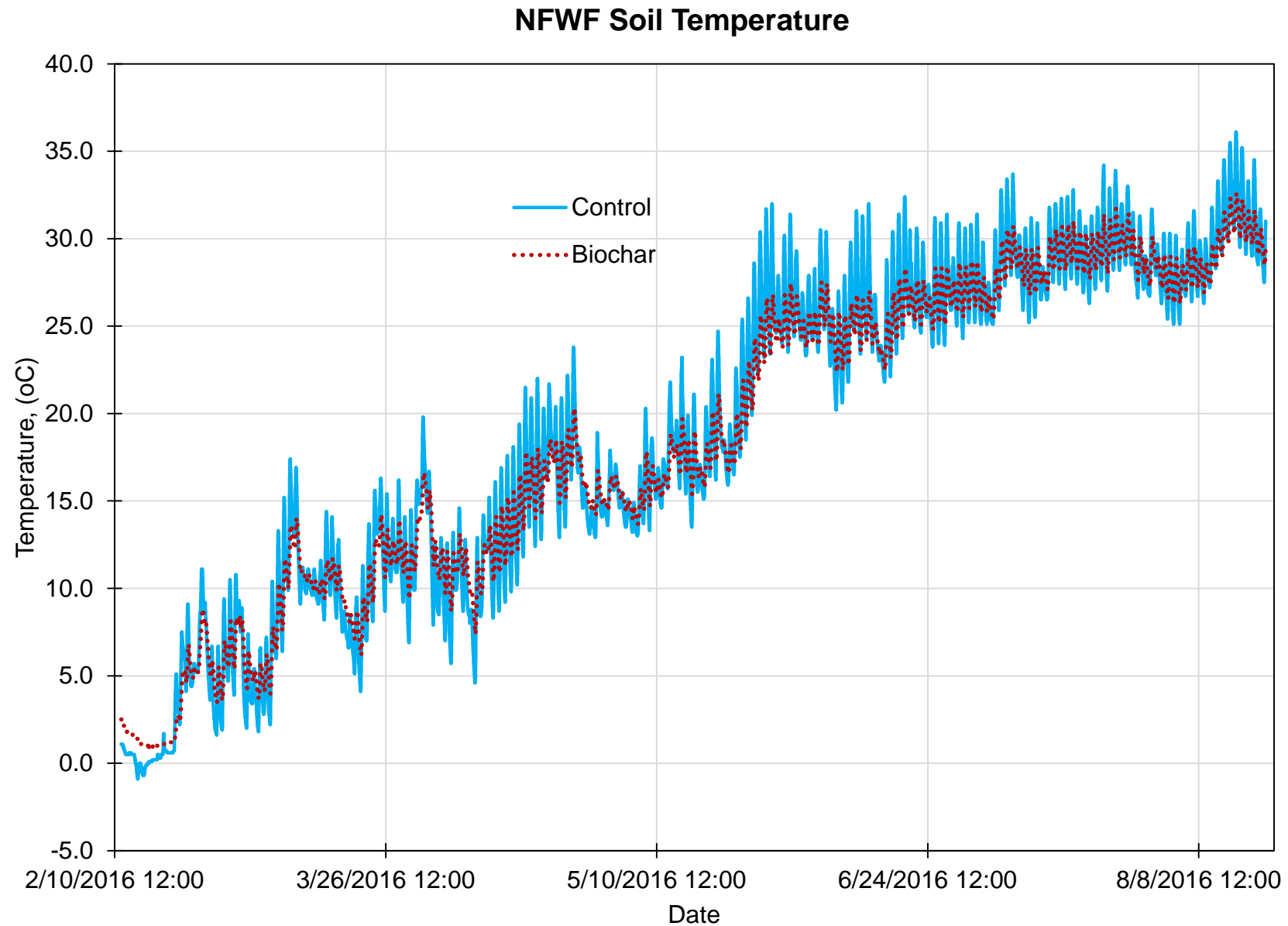
Existing Soil



Existing Soil with 4% Biochar



Results – Soil Temperature





Future Work

- Construct swales – Summer 2016
- Monitor and test throughout 2016
- Author recommendations for regulatory credit applications for use of Biochar
- Model the hydrodynamics of stormwater flow and infiltration using Richards equation and results from lab and field experiments



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